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Mosaic and Related Diseases of Raspberries in Washington

by

Leon K. Jones and Karl E. Baur

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[1] In cooperation with the State Committee on the Relation of Electricity to Agriculture.
[2] In cooperation with the United States Department of Agriculture.
[3] Regional Director, Conservator, Soil Conservation Service, U. S. Dept. of Agriculture.
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MOSAIC AND RELATED DISEASES OF RASPBERRIES IN WASHINGTON [1]

by

Leon K. Jones and Karl E. Baur[2]

INTRODUCTION

A study of the bramble-fruit industry of the United States shows a similarity in the rise and decline of the raspberry-growing industry in the various areas. Whereas in 1900, Wisconsin had from 1500 to 2000 acres of bramble fruits, these had declined to 964 in 1909 and to about 200 acres in 1919 (6).[3] Raspberry growing in the Hudson River Valley of New York was a thriving industry in 1900 (12). Since 1900, the Marlboro variety and then the Perfection variety have "run-out" until there was hardly a commercial planting of raspberries in that area in 1927 (9). The raspberry acreage in New York State declined 37 per cent from 1899 to 1929 and the acreage in Ohio, Pennsylvania, New Jersey, and the New England states declined 36 per cent in a similar period of time. The total production in the above-mentioned areas decreased 60 per cent in the 30-year period although the population increased 63 per cent (11).

The decline of the industry is marked by a gradual decrease in yields usually described as "running out" with the result that the growers become discouraged and turn to other crops. This performance of varieties has been caused largely by the presence of virous diseases. It has been shown (3) that the yield of mosaic-infected red raspberry plants may be decreased 14 to 28 per cent from that of mosaic-free plants, and also that infected plants produce fruit of reduced quality with insipid flavor.

Virous diseases of raspberries were described in the literature as "curl" in 1895 (4) and "yellows" in 1902 (12). Not until 1922, however, were curl and mosaic differentiated from the "yellows" complex (8). During the last decade, investigators have shown that there are several distinct types of virous troubles of raspberries, although they have not

[1] Cooperation of the Extension Service of The State College of Washington, the State Department of Horticulture, the berry grower's associations in the Puyallup Valley, and Mr. J. G. Harris of Yelm, Washington in the various phases of these investigations is gratefully acknowledged.

[2] Field assistant in the Agricultural Extension Service, The State College of Washington.

[3] Reference made to literature cited, page 19.

been in complete agreement regarding the number of viruses involved. The latest publications (1, 2, 9, 10) recognize eight virous diseases of raspberries, as follows: (1) yellow mosaic; (2) mild red raspberry mosaic; (3) medium severe red raspberry mosaic; (4) severe red raspberry mosaic or red raspberry mosaic; (5) leaf curl, alpha type; (6) leaf curl, beta type; (7) mild streak; and (8) severe streak.

Mosaic of raspberries is caused by an infectious principle, called a virus, the exact nature of which is not known. The virus is readily transmitted from plant to plant by the feeding punctures of aphids (*Amphorophora rubi, A. sensoriata, A. rubicola*), the first of which is generally present in raspberry plantings in Washington. Investigators have been unable to transmit raspberry mosaic from plant to plant in any way except by means of aphids or by grafting, although many other viruses can be transferred by mechanical contact or by rubbing the juice from diseased plants onto healthy ones. The aphids suck the juice from the diseased plants for their food and thus become carriers of the disease-producing virus, which they may transmit to healthy plants on which they feed. Yellow mosaic is transmitted by the aphid, *Amphorophora rubi*, leaf curl by *Aphis rubiphila*, but no insect vectors are known for the streak-producing virus.

Red raspberry mosaic has caused the elimination of the Cuthbert variety in the Spokane Valley and of black raspberries in various parts of Washington. It appears safe to conclude that the Cuthbert will also be eliminated in western Washington unless mosaic is checked or eradicated.

SYMPTOMS

Mosaic

Red raspberry plants affected with mosiac show a marked mottling of the leaves with raised dark green areas, and somewhat depressed light green areas, thus appearing lighter green than normal (Fig. 1); and they are generally somewhat stunted and produce less fruit which is of lower quality. The light areas tend to be adjacent to the veins with the dark areas in the interveinal-tissue. This mottling of the leaves is more pronounced on the foliage of new cane growth than on the old fruiting wood, especially if the new cane growth is made during cool weather, while little or no mottling will be present on leaves that are formed during hot weather. Ordinarily mosaic symptoms do not become pronounced on the new canes in the spring until they have reached a height of one foot or more, which is in the early part of June in western Washington.

The foliage of black raspberry plants affected with mosaic is mottled with light and dark green areas (Fig. 2), and the leaf petioles

and canes may be discolored with reddish-brown to black spots or elongated blotches. The cane tips are shortened, become brittle, and often turn black (Fig. 3). Often the cane tips are not killed but a shortening of growth with a rosetting of foliage at the point of inoculation may be followed by nearly normal growth of the affected shoot (Fig. 4). This often happens with plants of the Cumberland, Dundee, Naples, Kansas, and Ohio varieties, whereas on the Munger and Plum Farmer varieties the usual symptom is the killing of tips. Affected black raspberry plants often produce little or no new growth the second year (Fig. 5) and may die the second or third year following infection. In the later states of the disease an abundance of dwarfed, narrow, rosetted foliage may appear on the old canes prior to their death.

Leaf Curl

The leaves on the suckers and fruiting canes of affected plants are much darker green than normal, are wrinkled, remain dwarfed, and are cupped downward at the margins (Fig. 6). Canes of affected plants may be stunted and the distance between leaves considerably shortened. Plants affected with this disease show no mottling of the foliage.

Yellow Mosaic

An indefinite mottling of the leaves with light and dark green areas and a stunted, yellowed appearance of the plant is associated with this trouble on red raspberries. The mottling differs from mosaic in the following features: the light areas become abundant at the edges of the leaves and are to be found to a greater degree in the interveinal tissue (Fig. 7); the dark green areas are not raised; and the symptoms are not masked by summer temperatures.

Affected black raspberry plants are severely dwarfed and have laterals and foliage more upright than normal. The leaflets are longer and narrower than normal, variously distorted and curled, and yellowish-green, which gives a distinct yellowed appearance to the plant. The fruit produced on affected plants is worthless because of a dry, seedy character and an insipid flavor.

Streak

Definite symptoms of this disease appear on black raspberries the year following infection. The new canes are slightly less vigorous and the tip leaves in midsummer show a tendency to be sharply bent downward.

There is no mottling of the leaves, but they are darker green than normal and are curled with the midribs arched downward and petioles shortened. The canes of affected plants are shortened, being arched

and the leaves clustered closer together than is normally the case. Bluish, pencil-line streaks are often found on the canes, and affected plants decline in vigor to the extent that they are severely dwarfed in two or three seasons.

Physiological Mottling

A mild mottling of the first leaves produced on fruiting canes and older leaves of the new canes is often noted on a high percentage of red raspberry plants. Small indefinite light areas are scattered in more or less abundance through normal green tissue (Fig. 8). This symptom has fluctuated from season to season and during any given season, but appears to have no detrimental effect. Observations on marked plants during the last six years have led to the conclusion that this type of mottle is not caused by a virus and is in no way related to the mosaic disease.

Mottle or chlorosis of another type that shows as light chlorotic areas in portions or nearly all of the interveinal tissue (Fig. 9) is common on the foliage of fruiting canes, and is sometimes confused with mosaic mottle. This discoloration which may be light green, yellowish, or even reddish is not caused by a virus but by a disturbed nutritional balance.

OCCURRENCE IN WASHINGTON

Observations on raspberry plantings in Washington have been made during the last six years to determine the prevalence of virous diseases, with the following results:

1. Red raspberry mosaic is the most prevalent and destructive virous disease of red and black raspberries in Washington. It is present in about 41 per cent of 1400 plantings in Pierce County; abundant in plantings of red and black raspberries in Thurston, Spokane, Whitman, and Asotin Counties and in the southern part of King County, including Vashon Island; abundant in the plantings of the Syracuse variety near Alderwood Manor in Snohomish County; present in a few plantings in Mason and Skagit Counties and in one planting of black raspberries near Lynden in Whatcom County (Fig. 10). Observations have not been made in Benton, Stevens, Yakima, Walla Walla, and Jefferson Counties; however, specimens affected with mosaic have been received for diagnosis from these counties.

2. Leaf curl has been noted on the Latham variety near Spokane, near Puyallup, and, in one planting of Cuthberts which was severely damaged by the disease in 1935 near Clarkston. The aphid, *Aphis rubiphila,* which is responsible for the spread of this disease, has been commonly observed in the Spokane Valley, but frequent observations have failed to note its presence in western Washington.

3. Yellow mosiac occurs commonly in the Spokane Valley and near Pullman, but has not been observed in western Washington.

4. Streak is present on black raspberries in Spokane and Thurston Counties, but is of relatively minor importance in comparison to the damage done by the true mosaic disease.

5. A mild mottling of red raspberry foliage, which is often present in western Washington has previously been referred to as mild or medium severe mosaic (7), but is probably a physiological response to growing conditions and is not caused by a virus.

Observations on a high percentage of the raspberry plantings near Vancouver, Startup, Monroe, Kirkland, and Everson have failed to show mosaic. A few plantings have been examined near Rochester, Elma, Sequim, Coupeville, Olympia, and Burlington, and on Bainbridge Island without the detection of mosaic (Fig. 10). In many cases of mosaic-infected plants it was found that the disease could be traced to some planting that was originally made with stock introduced from the central part of the United States during the last 15 or 20 years. The introduction of the disease into one planting in an otherwise mosaic-free area near Mount Vernon appears to have been due to the introduction of mosaic-carrying aphids on crates brought from infected fields in another county.

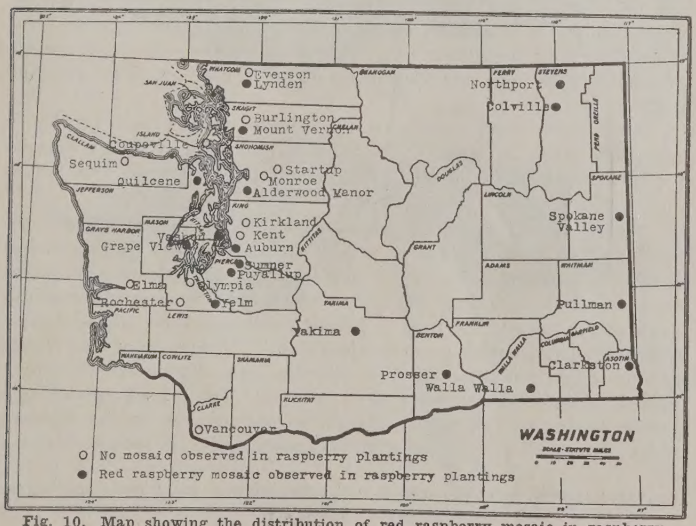

Fig. 10. Map showing the distribution of red raspberry mosaic in raspberry plantings in Washington.

The Spread of Mosaic

This disease is spread to new plantings mainly by the use of infected nursery stock taken from fields that show more or less mosaic. Once a plant becomes affected, the disease spreads to all parts including new growth produced in future seasons. Aphids that are carrying the virus may be transferred from affected fields to healthy fields on picker's clothing, crates, and other materials used in the culture or harvesting of the crop; and this fact appears to account for a small amount of disease-spread from field to field and for a greater degree of spread in affected fields.

The aphid, *Amphorophora rubi,* which spreads the mosaic virus from plant to plant has been observed in raspberry plantings in all areas of Washington covered by the surveys. This insect lives over winter in the egg stage on the canes, and the adults usually appear on the plants during the last week of June or early July. They may become abundant on the under-surfaces of leaves on the tips of growing canes in July and August. Reports by other investigators have shown that the aphids usually move only to adjacent plants of their own accord, although wind and cultural practices may be responsible for their transfer to greater distances.

In order to test the infectivity of the aphids commonly found on raspberries in western Washington, a number were moved from mosaic-infected red raspberry plants to 12 healthy black and red raspberries at the Western Washington Experiment Station during July, 1930. Eleven of the plants so treated developed symptoms of mosaic in August, 1930, but some 800 control plants in the same field remained healthy.

Since it has been noted that the disease spreads more rapidly in some areas than in others (9), it appeared advisable to obtain data on the rate of spread in mosaic-infected plantings under western Washington conditions.

During the fall of 1929, a trial planting of Plum Farmer and Cuthbert raspberries was made at the Western Washington Experiment Station to determine the rate of spread of mosaic following its introduction into the planting.[1] Mosaic-infected plants were introduced into some of the rows at the time of planting, whereas some adjacent rows were free of the disease as shown in Table 1. Observations and counts of mosaic-infected plants in this field were made during June for three years and the following facts were noted: (1) The disease spread each season to one or two plants along the row adjacent to the diseased plant. In the five rows of Cuthbert raspberries in which diseased

[1] Acknowledgement is given to Geo. A. Newton, formerly Plant Pathologist at the Western Washington Experiment Station, for his efforts in starting the trial planting.

Fig. 1. Red raspberry mosiac showing as mottling and puckering on Cuthbert leaf.

Fig. 2. Red raspberry mosiac mottling of black raspberry leaves of the Munger variety.

Fig. 3. Blackening and killing, dwarfing, and reddish-brown spotting show as symptoms of red raspberry mosaic on cane tips of black raspberries in the row at the right. The tip at the left is healthy.

Fig. 4. Red raspberry mosaic showing as stunting and rosetting on a cane tip compared with a healthy tip of black raspberries.

Fig. 5. Stunting and dwarfed condition of fruiting canes and failure to produce new canes the second year following infection of Plum Farmer black raspberries with the red raspberry mosiac.

Fig. 6. Leaf curl showing as dwarfing and arching of leaves on a Cuthbert cane.

Fig. 7. Yellow mosiac mottling on red raspberry leaves.

Fig. 8. Physiological mottling of Cuthbert raspberry leaves as a result of environmental factors.

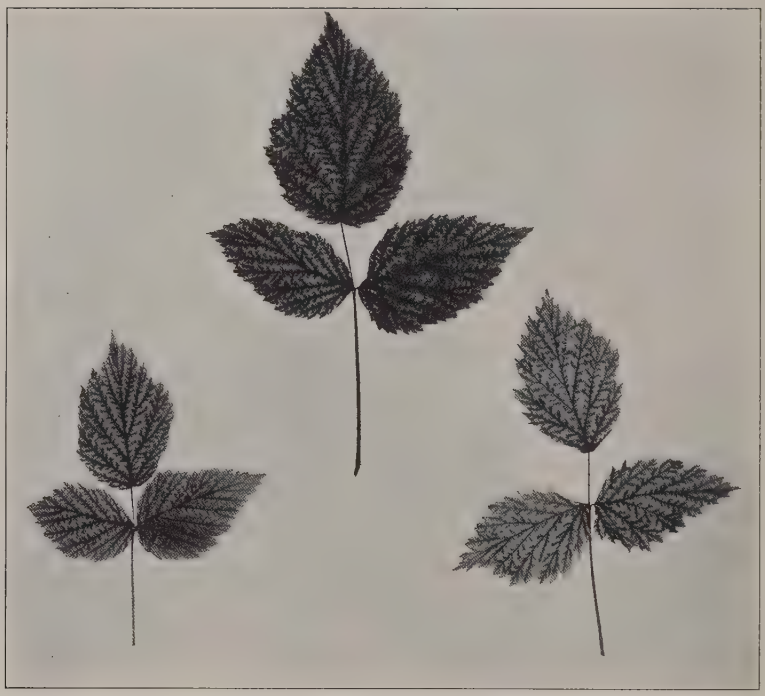

Fig. 9. Chlorosis of Cuthbert raspberry leaves as a result of unbalanced nutrition in the plant.

Table 1. The Rate of Spread of Mosaic in an Experimental Planting of Plum Farmer and Cuthbert Raspberries—Puyallup, Washington[a]

Plum Farmer

xxx-mmmxxxxxxxm-m-m-x-xxx xxxxxxxxxmmxx----xxxxmxxxxxxxxxxxxxxxxxoxx xxx xx-xxx

Plum Farmer

xxxxxxxxxxxxxxxxxxxxoxxxoxxxxxxxxoxxx xxxxxxxoxxxxxoxxxx xxxxxxoox-xxx--xx

Cuthbert

---mxxmmxxxoxmm--mmxxoxmmxxmmxxoxxm---mmxoxm------mo-----mmmox---------o----

Cuthbert

--xmxoxx----mxoxm-mm--mxo-mxxmm--xoxmmm--m-moxm-----mxoxmm-----mxo------

Cuthbert

-m-xxxoxxmm-m-xxox------mmox -- xx--xom------mxoxm------mom-------mo----

Cuthbert

--xxoxxm-m--mmoxmm------xoxmx---m-xox--x---mmo------mxxox---x----------

Cuthbert

---mxomxmmx-xmmoxm------moxm-----mmoxm----mmxox------ xo-x -----xo-----

Cuthbert

----mx-------mxmmm--------xm----------

Cuthbert

---------- ---------- -----

Cuthbert

------ ---------- --------- ---------- --------- -----

Cuthbert

---------- --------- --------- --m---------- -----

Cuthbert

xo---------- ------mom- omm-o --o- -o---m-o-mmo------

Plum Farmer

xxxxmmxxxxoxxxxxomxx mmmx--mmmmxx xxxxxx xxxxxmm-- x

[a] Planting made in October, 1929. o, shows mosaic-infected plants placed in rows at time of planting or inoculated with mosaic during the spring of 1930. x, shows plants which became naturally affected with mosaic between June 20, 1930 and June 25, 1931. m, shows plants that became affected with mosaic between June 25, 1931 and June 23, 1932. -, shows mosaic-free plants, June 23, 1932.

plants were placed at planting time the mosaic-infected plants increased from 9.5 per cent in 1930 and 28.3 per cent in 1931 to 51 per cent in 1932. (2) The disease spread considerably more rapidly in the black raspberries than in the red raspberries. In the three rows of Plum Farmer the mosaic-infected plants increased from 5.5 per cent in 1930 and 80.5 per cent in 1931 to 92 per cent in 1932. (3) Whereas mosaic spread very rapidly along the row of Cuthbert plants in which diseased plants were placed there was relatively very little spread from plants in such a row to plants in the adjacent rows of Cuthberts, but quite rapid spread to adjacent rows of Plum Farmer.

Observations on a two-acre planting of Cuthberts in the Spokane Valley showed that mosaic infection increased from two to 95 per cent between the summers of 1929 and 1934.

A survey of many of the raspberry plantings in Pierce County in 1934 and 1935 showed that the number of mosaic-infected plants more than doubled in the one year (Tables 2 and 4). The increase in diseased plants in a given field was 104 per cent and the average increase in 11 fields was 148 per cent.

It has been noted during the surveys that the disease appeared to spread less rapidly in the Marlboro variety. Detailed records were kept on a large Marlboro planting near Sumner, Washington, from 1931 to 1934 (Table 3), which showed that mosaic spreads somewhat less rapidly in the Marlboro than it does in the Cuthbert.

These observations show that once mosaic is introduced into raspberry plantings in Washington it will spread as rapidly as it does in other areas of the United States (9).

VALUE OF ROGUING

It has been shown by workers in the eastern United States (9, 11) that the removal of mosaic-infected plants from fields may check the development of the disease. Detailed observations were made on a number of fields in Pierce County to determine the value of roguing. In each case the diseased plants were marked and the grower removed them along with one healthy plant on each side of the diseased plants in June or July. The results of roguing a given field (Table 2) show that the number of diseased plants noted in 1934 and 1935 was reduced 82 per cent by the one roguing in 1934. In 16 fields from which the diseased plants were rogued in 1934, observations in 1935 showed that the number of diseased plants had been decreased an average of 56 per cent and that the disease was eradicated from five of the plantings (Table 4). This shows a marked reduction in the amount of disease present when compared to the 148 per cent increase in diseased plants in the 11 fields that were not rogued (Table 4). Better results could have been obtained if all the roguing had been done before the aphids appeared on the plants and if more care had been used by the growers in keeping down sucker growth from the roots of rogued plants. Observations on roguing lead to the conclusions: (a) that the disease may be practically checked and often eradicated from plantings having less than five per cent of the plants affected; (b) that fields having high percentages of the plants affected cannot be profitably rogued.

VARIETAL SUSCEPTIBILITY

A consideration of the susceptibility of varieties deals with the rate of spread of the disease from plant to plant and the effect of the

Table 2. The Spread of Mosaic in Cuthbert Plantings, Puyallup, Wn.

Not rogued			Rogued		
Row No.	No. of mosaic-infected plants		Row No.	No. of mosaic-infected plants	
	1934	1935		Removed in 1934	Present in 1935
12-13	3	27	1-2	8	8
14-15	30	34	3-4	0	0
16-17	20	57	5-6	5	0
18-19	6	27	7-8	0	1
20-21	20	40	9-10	18	5
22-23	13	44	11-12	0	1
24-25	1	20	13-14	0	2
26-27	2	16	15-16	11	0
28-29	1	7	17-18	13	0
30-31	8	18	19-20	2	0
32-33	40	47	21-22	3	1
34-35	38	46	23-24	1	0
36-37	4	16	25-26	3	0
38-39	5	13	27-28	0	0
40-41	2	10	29-30	0	0
42-43	19	19	31-32	0	0
44-45	13	17	33-34	0	0
46-47	14	16	35-36	0	0
48-49	1	9	37-38	0	0
50-51	7	18	39-40	0	0
52-53	0	7	41-42	16	1
54	0	0	43-44	13	0
55-56	9	15	45-46	0	0
57-58	0	1	47-48	4	0
59-60	0	4	49-50	3	0
61-62	0	3	51-52	8	0
63-64	0	0	53	0	0
65-66	0	1	54-55	12	2
67-68	0	0	56-57	14	2
69-70	0	0	58-59	0	1
			60-61	0	0
Total	256	523	62-63	0	0
			64-65	2	0
			66-67	0	0
			Total	136	24

Table 3. The Spread of Mosaic in a Marlboro Planting, Sumner, Washington[a]

Year of observation	No. of plants observed and destroyed	No. of plants observed but not removed	Percentage decrease or increase in infected plants
1931	122		
1932	92		—25
1933		112	+21[b]
1934		217	+94
1935		318	+47

[a] Notes taken on a planting containing about 7300 plants.
[b] Increase of mosaic following roguing probably due to failure to keep down suckers coming from roots of rogued plants.

disease upon the plant. Observations on varieties in Washington lead to the conclusion that mosaic spreads very rapidly in Cuthbert; moderately fast in Marlboro, Syracuse, Latham and Chief; and slowly in the Antwerp and Newburg plantings. Based on mottling and dwarfing the effect of the disease is severe on Cuthbert, Marlboro, and Antwerp; moderate on Latham, Newburg, and Syracuse; and slight on Chief. Small plantings of the Lloyd George variety have been observed in Pierce, Snohomish, Whatcom, Kitsap, and Spokane Counties without the detection of mosaic. A mosaic occurs on the Lloyd George variety in England, and records from Canada and the United States show that this disease has been introduced to this continent in nursery stock but evidently it does not spread naturally under the new environmental conditions (5).

Since Latham and Chief are not seriously injured when affected with mosiac they have largely replaced the Cuthbert and Marlboro varieties in the Spokane Valley. The very slow spread of mosaic to the Antwerp might also lead to the use of this variety in areas where mosaic is abundant in established plantings of other varieties. The Lloyd George variety appears to be the most promising red raspberry variety from the standpoint of mosaic resistance; however, further tests dealing with fruit production and quality are necessary before recommending its general use.

Black raspberries are more susceptible to infection by mosaic than are red raspberry varieties. The results of tests reported in Table 1 show that the disease spreads much more rapidly on Plum Farmer than on Cuthbert plants.

A trial planting of black raspberries was made on the J. G. Harris farm near Yelm, Washington, April, 1934, in order to study the relative susceptibility of promising black raspberries to mosaic infection.

Table 4. Comparison of the Spread of Mosaic in Cuthbert Fields that Were Not Rogued with Rogued Fields. Puyallup Valley, Washington

Not rogued			Rogued		
Field No.	No. of mosaic-infected plants		Field No.[a]	No. of mosaic-infected plants	
	1934	1935		Removed in 1934	Removed in 1935[b]
1	70	108	1	3	7
2	2	10	2	17	20
3	2	4	3	26	0
4	34	154	4	46	0
5	17	29	5	8	0
6	22	65	6	13	12
7	238	544	7	4	0
8	371	571	8	2	0
9	4	35	9	7	2
10	39	435	10	128	112
11	19	74	11	22	3
			12	1	1
Total	818	2029	13	17	3
			14	136	24
			15	6	2
			16	3	7
			Total	439	193

[a] The size of fields varied from one-half acre to 10 acres.
[b] Poor results obtained by some growers traced to one or more of the three following factors: (1) did not rogue early in season before the appearance of aphids; (2) did not remove one healthy plant from each side of the diseased plants; and (3) did not keep down sucker growth from the roots of affected plants that had been removed.

Plants of the Cumberland, Naples, Dundee, and Munger varieties were used in the order named, but mosaic spread so rapidly in the Munger plants and so increased the percentage infection in the adjacent row of Dundee plants that it seemed advisable to remove the Munger variety from the trials. Observations on this planting in June and August each summer have shown that the Munger variety is considerably more susceptible than the other varieties tested. During the spring of 1935, plants of the Ohio variety were placed in the area from which the Munger plants had been removed. The Cumberland, Naples, and Ohio varieties appear to be less susceptible; however, sufficient observations have not been made on the Ohio variety to determine its comparative susceptibility (Table 5).

Table 5. The Rate of Spread of Red Raspberry Mosaic in a Planting of Black Raspberries, Yelm, Washington[a]

Variety[b]	No. of plants	No. of rows	Percentage of plants infected with mosaic			
			1934		1935	
			June 13	Aug. 22	June 24	Aug. 29
Cumberland	175	3	3.4	10.2	18.3	4.6
Naples	215	3	0.0	9.8	13.0	4.2
Dundee	216	3	0.4	18.5	36.5	3.2
Munger[c]	751	10	2.0	37.5		
Ohio[c]	562	10			0.0	0.8

[a] Plants set in field in April, 1934. All diseased plants were removed on the dates observed.

[b] Rooted tips obtained as follows: Cumberland from a planting at Gresham, Ore.; Naples, Dundee, and Ohio from N. Y. Agr. Exp. Sta., Geneva, N. Y.; and Munger from mosaic-free mother plants at Yelm, Washington.

[c] Munger plants removed in fall of 1934 and land reset to Ohio plants in April, 1935.

The Munger variety has been grown almost exclusively in the vicinity of Yelm for the last 12 years. At the present time the plantings are severely damaged by mosaic and unless some less susceptible variety is used it appears that black raspberry growing in that area will be discontinued in a very few years.

CONTROL

In starting new plantings, extreme care should be used to obtain plants known to be free from red raspberry mosaic. Since the disease is carried in nursery stock taken from diseased plants, only mosaic-free plantings should be used for propagation. Recent rulings by the State Department of Agriculture make it unlawful to sell raspberry plants from fields that have not been inspected and found to be free from mosaic. A list of inspected and certified stock may be obtained from the State Department of Agriculture, Olympia, Washington.

No chemical sprays are of value in controlling mosaic once it has become established in the plant. To eradicate the disease from a field the affected plants should be dug out and destroyed and the following precautions should be observed:

1. Roguing must be done as soon as symptoms of mosaic are observed in early summer and before the aphids appear on the plants, the most effective time usually being June in western Washington.

2. Careful inspection of plantings must be made at frequent intervals following roguing and any suckers destroyed that may come from roots of the rogued plants.

3. New plants may be set in the vacant areas caused by roguing as soon as all roots from the rogued plants have been destroyed and there is no chance of diseased suckers appearing in the row. Careful destruction of roots and suckers will ordinarily permit resetting the year following the removal of diseased plants.

4. It is of value to maintain a nursery row of one- or two-year-old plants at the edge of the field for resetting into the rogued areas. The resetting of two-year-old plants in the rogued areas reduces the time of unfruitfulness. Younger plants placed in the rows often do not develop well in competition with the older plants. If older plants are transplanted in the spring or summer, it is advisable to prune off the current season's fruiting wood and to water the soil around the roots.

5. If diseased plants are rogued during July and August they should be immediately removed from the field, with care to prevent contact of the diseased plant with healthy plants, otherwise infective aphids may crawl or be brushed from the diseased plants onto healthy ones. Burning diseased plants in the field with a blow torch or spraying with a nicotine spray before removal during the time that aphids are abundant should be a valuable precaution.

6. One healthy plant on each side of the diseased plants in a row should be removed along with the diseased plants since they may have been recently infected and show little or no symptoms of the disease.

Since red raspberry mosaic is not generally established in plantings west of the Cascade mountains, all affected plants in that territory should be destroyed by digging and burning.

In the central and eastern part of Washington, where mosaic is generally established, mosaic plants should be dug out if less than five per cent are affected. In eastern Washington, if more than five per cent of the plants are affected, it is probably advisable to retain the planting until it becomes unprofitable, without attempting to control the disease. The Latham, Chief, Antwerp, Newburg, and possibly Lloyd George varieties may replace the more susceptible Cuthbert under eastern Washington conditions.

New plantings of mosaic-free nursery stock should be at least 300 feet away from old mosaic-infected plantings, a precaution which is especially important for black raspberries.

Aphids may be carried on the picker's clothing as well as on crates and boxes. Accordingly, pickers and materials should not be transferred from mosaic-infected to healthy plantings.

SUMMARY

Virous diseases have been a limiting factor in the growing of raspberries in central and eastern portions of the United States and have caused serious loss in some plantings in Washington.

Mosaic is generally present and destructive in eastern Washington but it also occurs in some of the raspberry-growing areas west of the Cascade mountains. Other virous diseases of less importance in Washington are yellow mosaic, leaf curl, and streak.

Results of observations on trial plantings and commercial fields show that mosaic spreads more rapidly on black raspberries than on red raspberries and more rapidly on Cuthbert than on Marlboro under western Washington conditions, and that it can be eradicated or materially reduced by careful roguing.

Of the red raspberry varieties observed, Cuthbert and Marlboro are the most seriously damaged; Latham, Chief, Syracuse, Newburg, and Antwerp are less affected by the disease, and the Lloyd George is free from the trouble. Observations on black raspberries have shown that the Plum Farmer and Munger varieties are seriously damaged, whereas the Cumberland, Dundee, Naples, and Ohio varieties are less damaged by the disease.

Control recommendations include the use of disease-free nursery stock, the destruction of mosaic-infected plants, the avoidance of the introduction of infective aphids into healthy plantings, and the use of less suceptible varieties if these are acceptable to the market.

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